Garfield studies of cell shape and superlayer transitions

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Outline

- Briefly review previously reported results:
  - Cell shape
  - Transitions between U and V stereo superlayers
- New:
  - Transitions between axial and stereo superlayers

- All calculations done by Philip Lu (UBC)

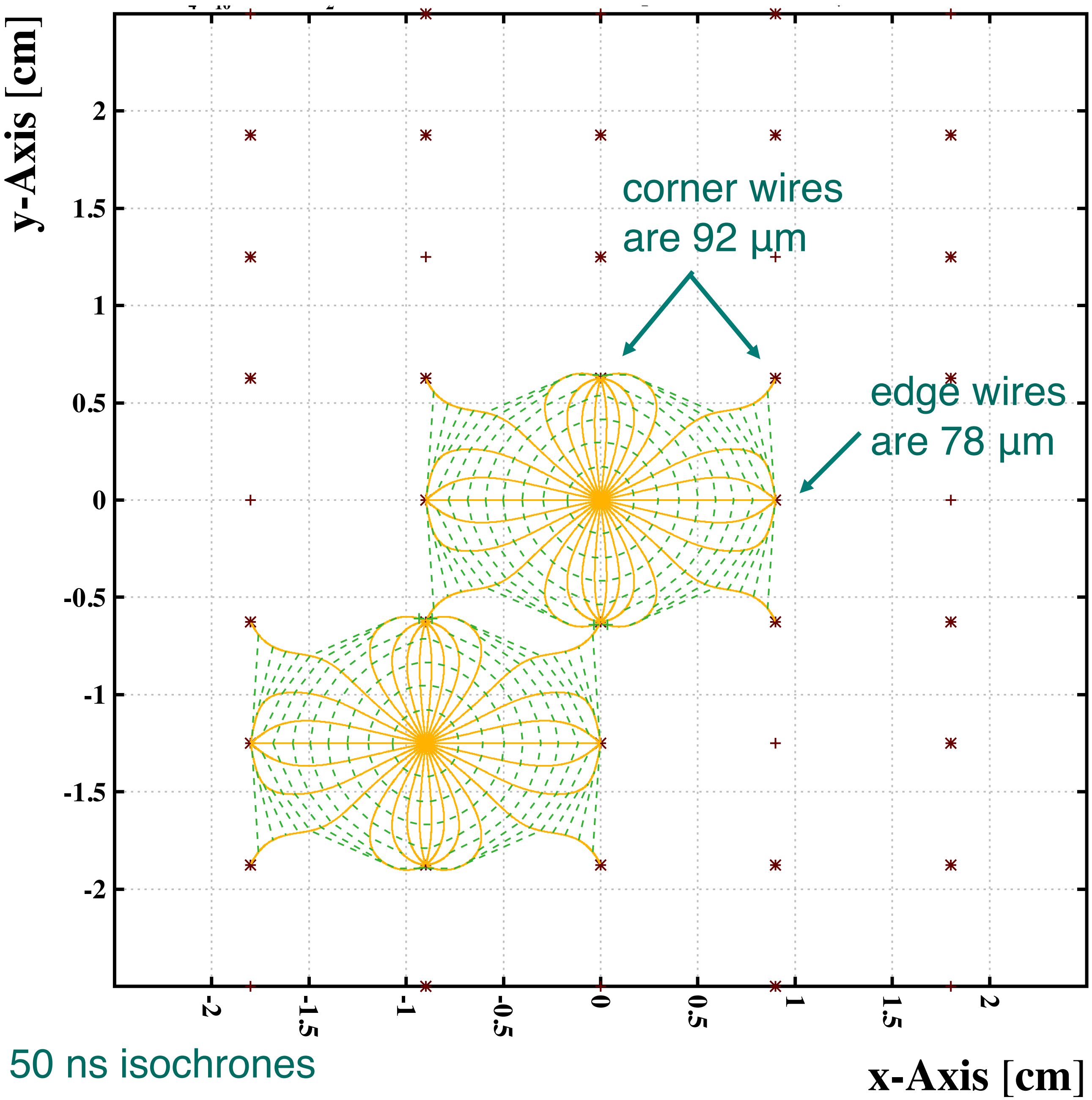
Common items

- Gas is He:Iso 90:10 with 3000 ppm water
- Sense wires are 20 µm gold-coated tungsten
- Field wires are bare Al 5056 with diameter selected to keep E < 20 kV/cm at the surface.
- B = 1.5 T

Cell shape

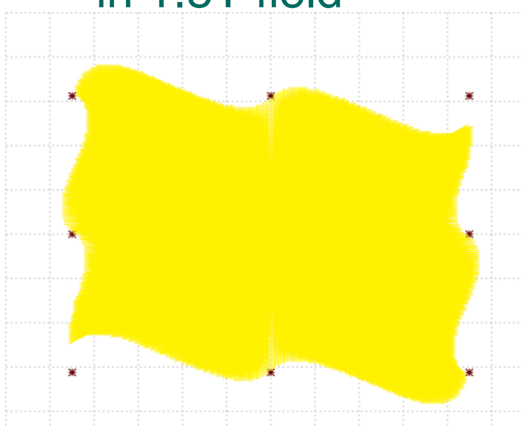
- Our preference is for rectangular cell with 3 field wires per sense wire.
- 10% less material and 20% less wire tension than hex
- Rectangular cell with 4:1 uses unacceptably fragile field wires, and does not allow for half-cell offsets between adjacent layers.

Rectangular cell, 3 field per sense 18 mm x 12.5 mm



50 ns isochrones

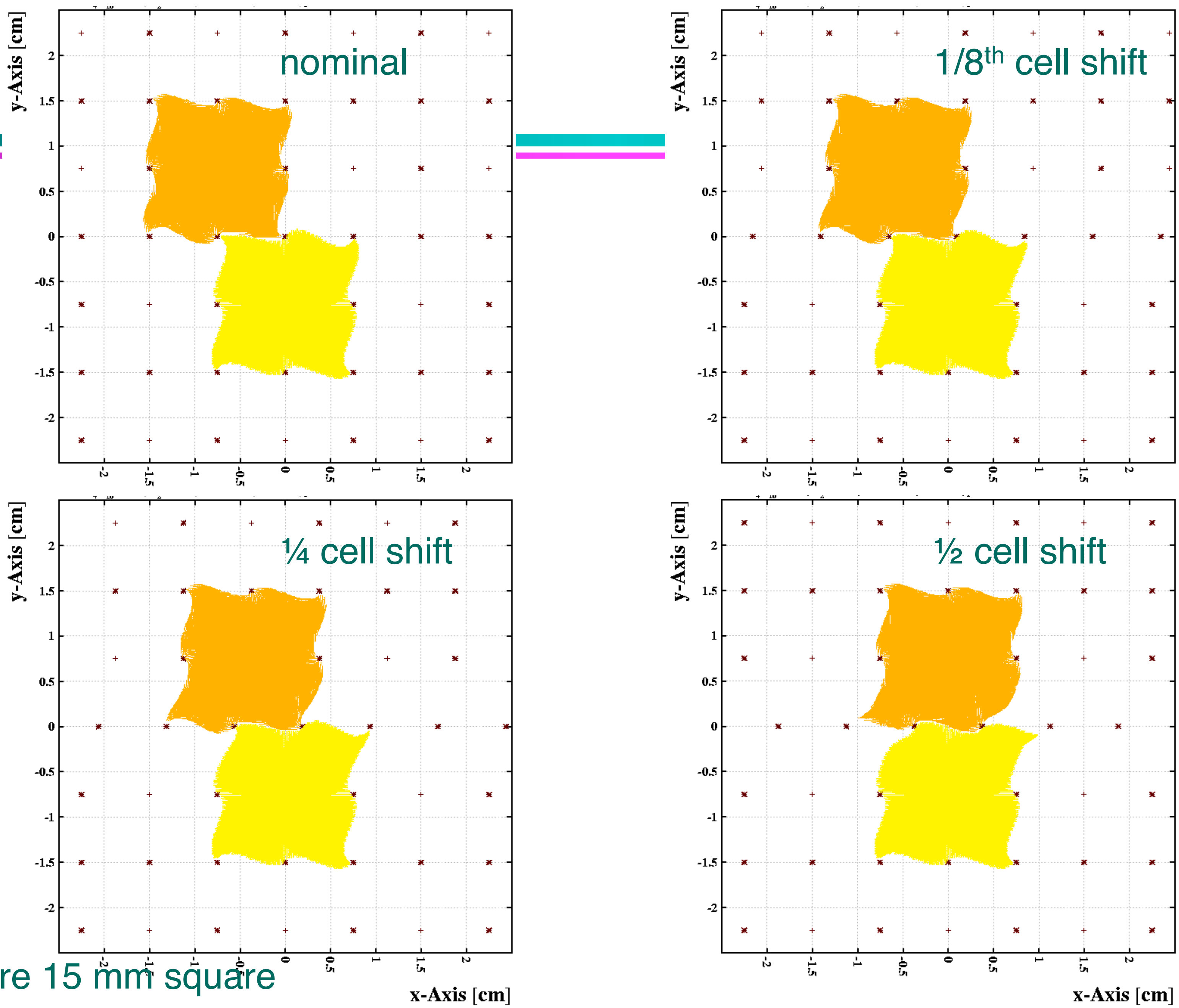
Actual cell shape
in 1.5T field



Transitions between stereo superlayers

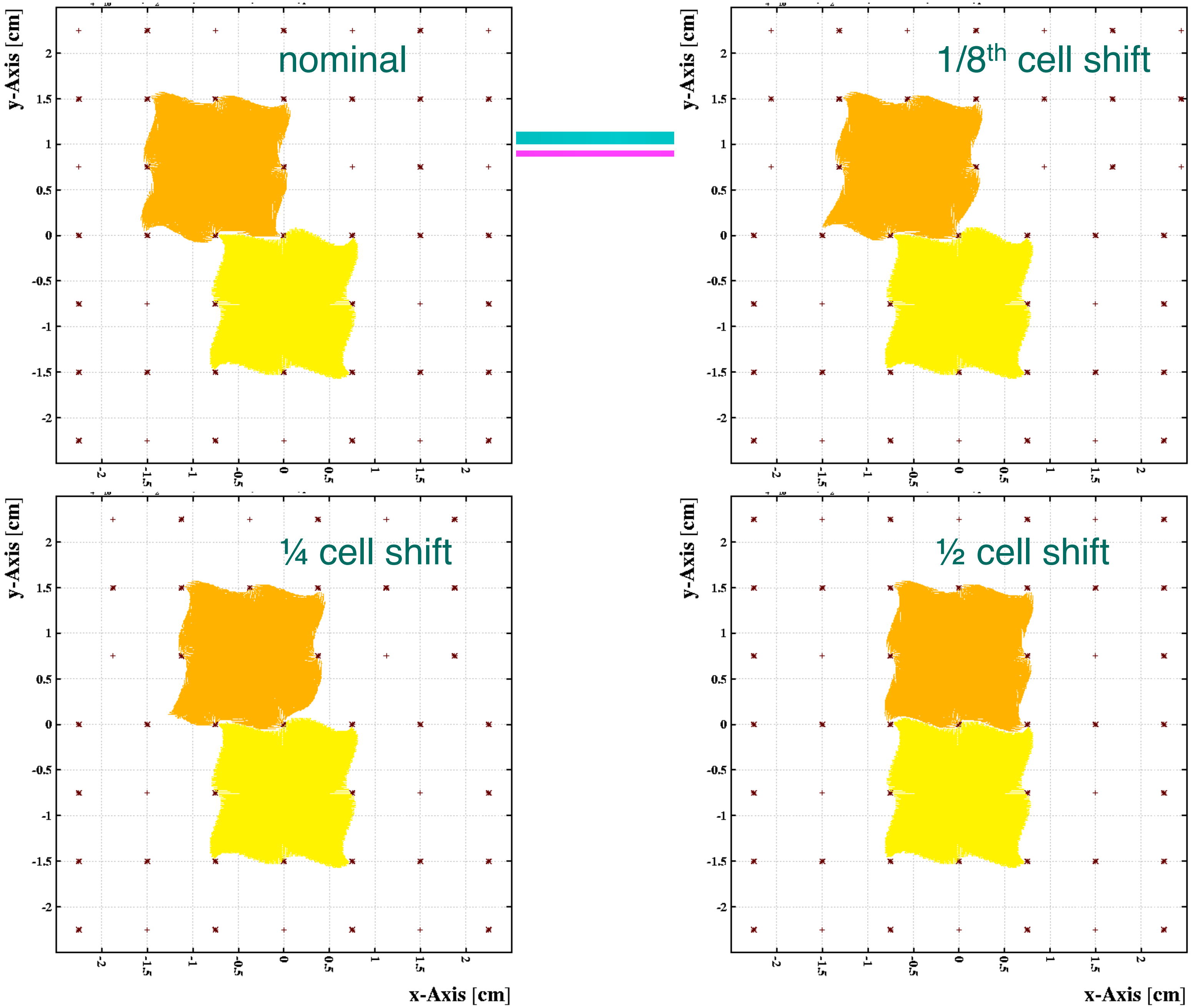
- Radial separation between sense wire in a U stereo layer and one in an adjacent V stereo layer is constant with z.
- Azimuthal separation changes with z.
- Field wire layer between them can have stereo angle of one of the sense wire layers, or mid-way between them.

Stereo-stereo layout 1: Field wires at intermediate stereo angle



cells are 15 mm square

Stereo-stereo layout 2: Field wires in phase with lower cell

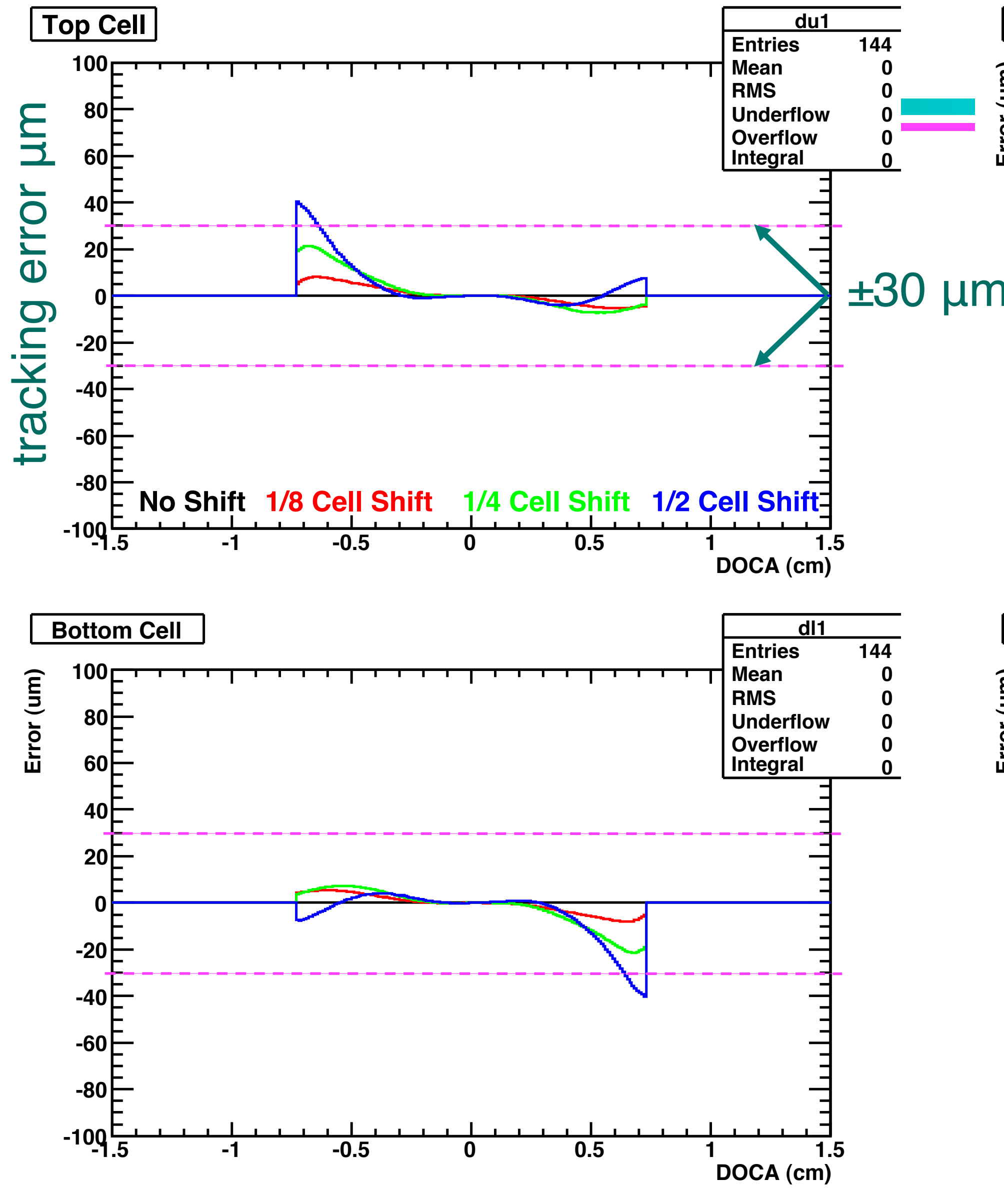


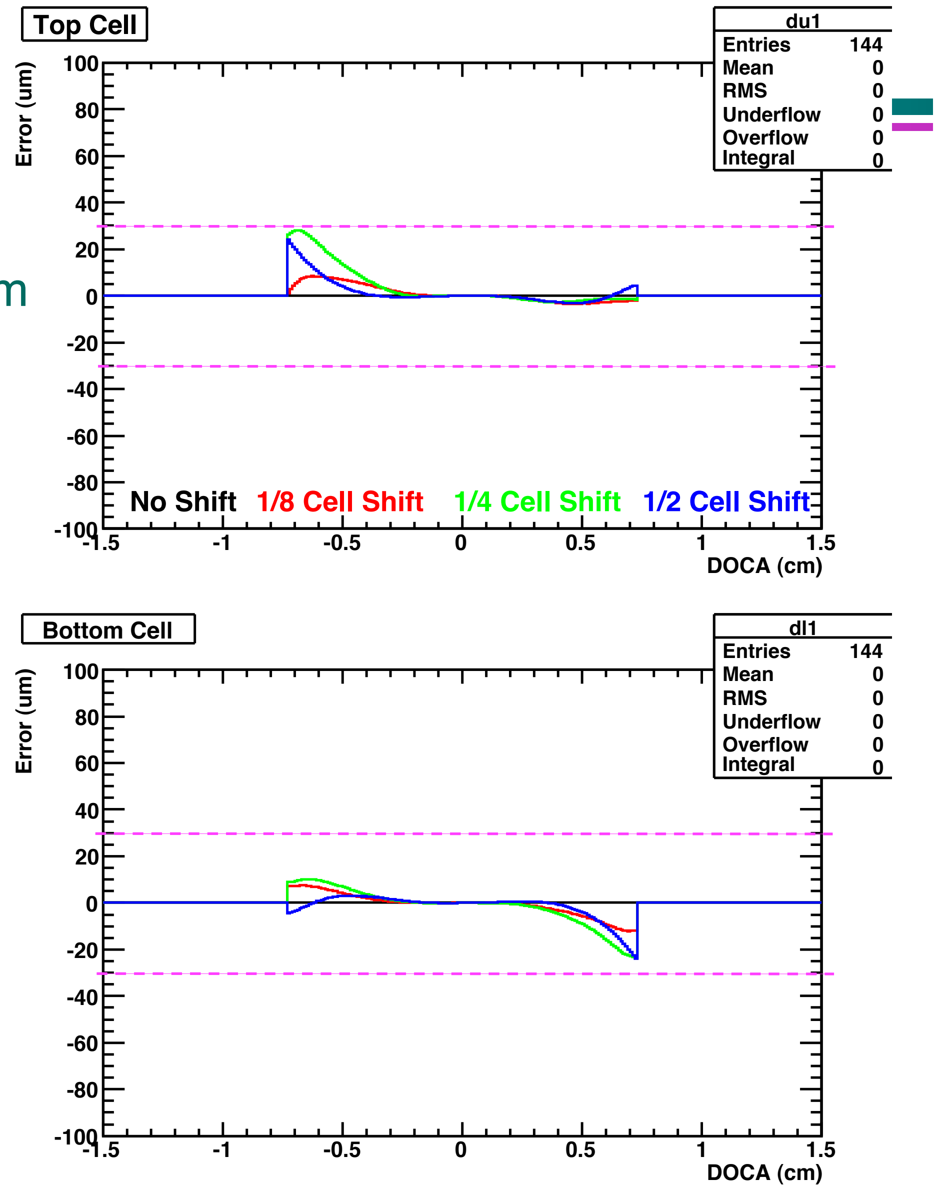
Impact on reconstruction

- Electric field and time-to-distance relationship depends on adjacent sense and field wires. Using the nominal TDR to reconstruct other cases will produce errors.
- For transitions between U and V superlayers with the same magnitude of stereo angle, these errors are < 40 µm for high-momentum tracks.

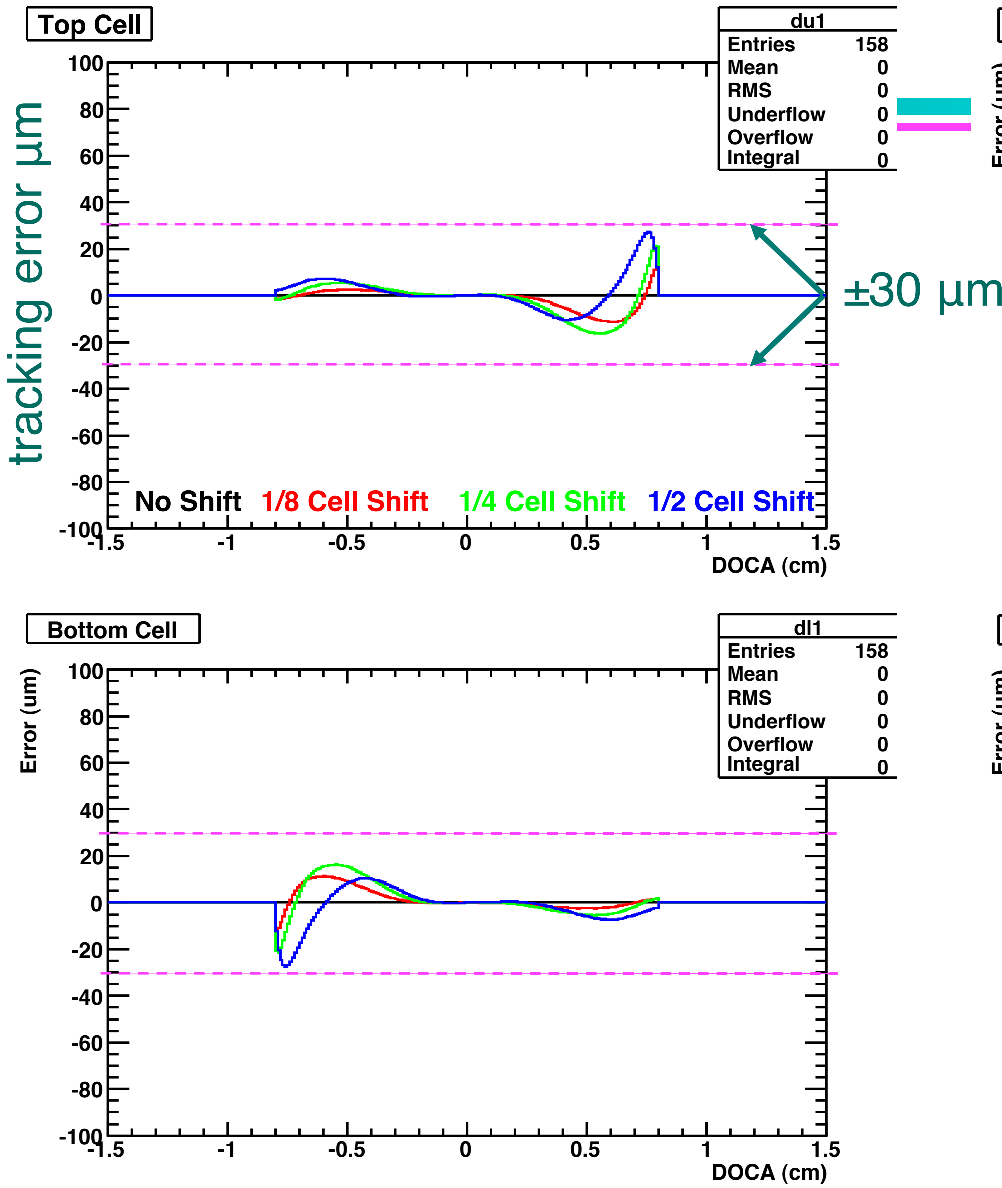
Layout 1: Field wires at intermediate stereo angle, 0° entrance angle

Layout 2: Field wires in phase with lower cell, 0° entrance angle

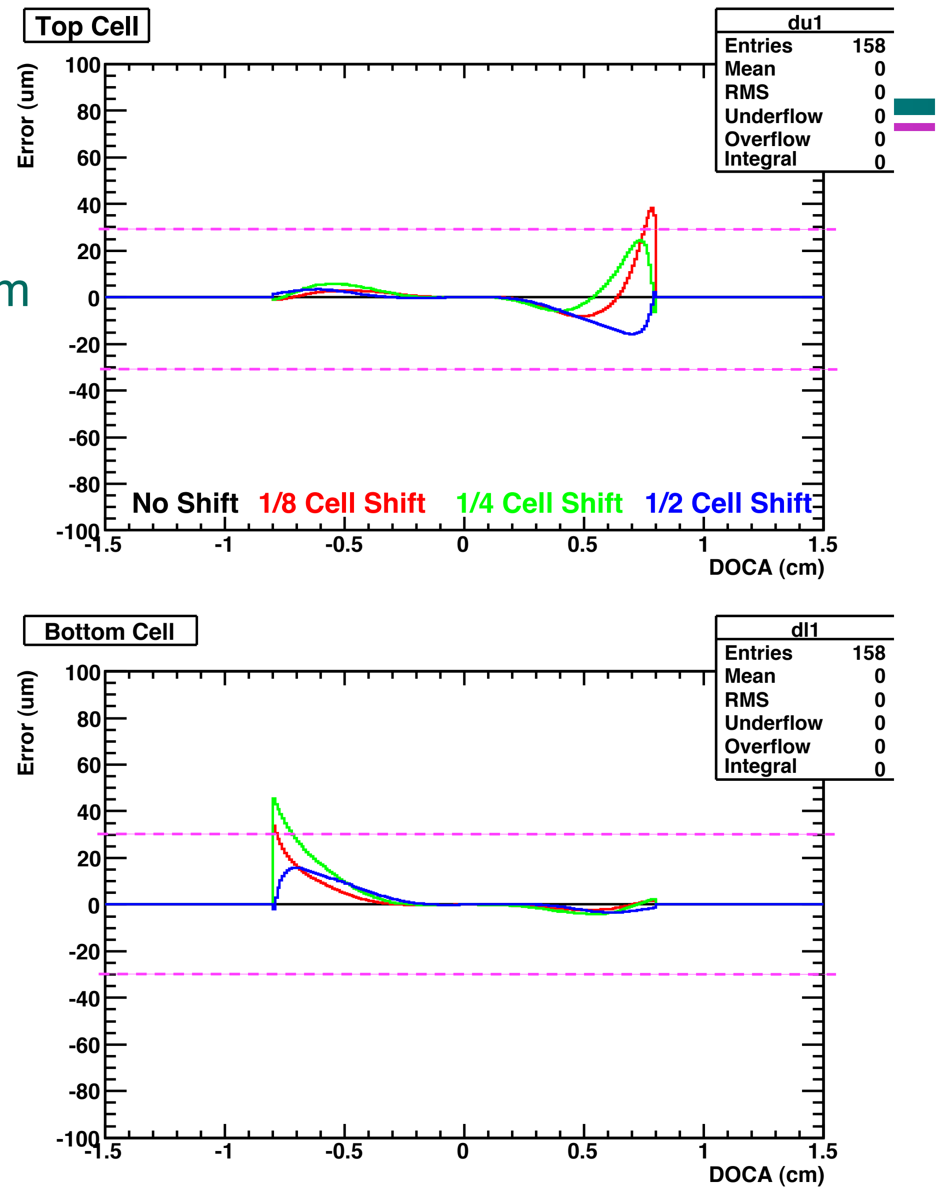




Layout 1: Field wires at intermediate stereo angle, 20° entrance angle



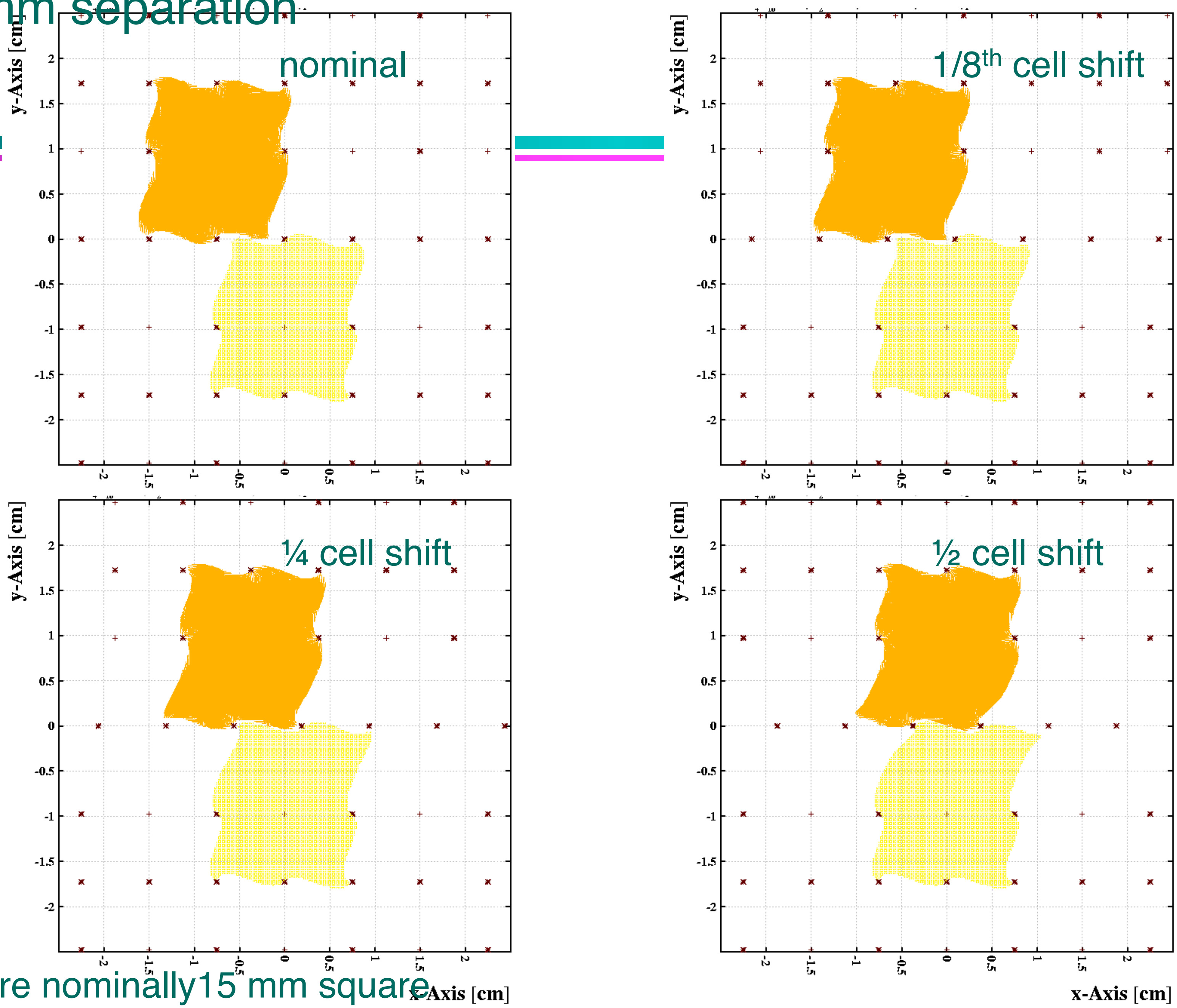
Layout 2: Field wires in phase with lower cell, 20° entrance angle



Axial/stereo transition

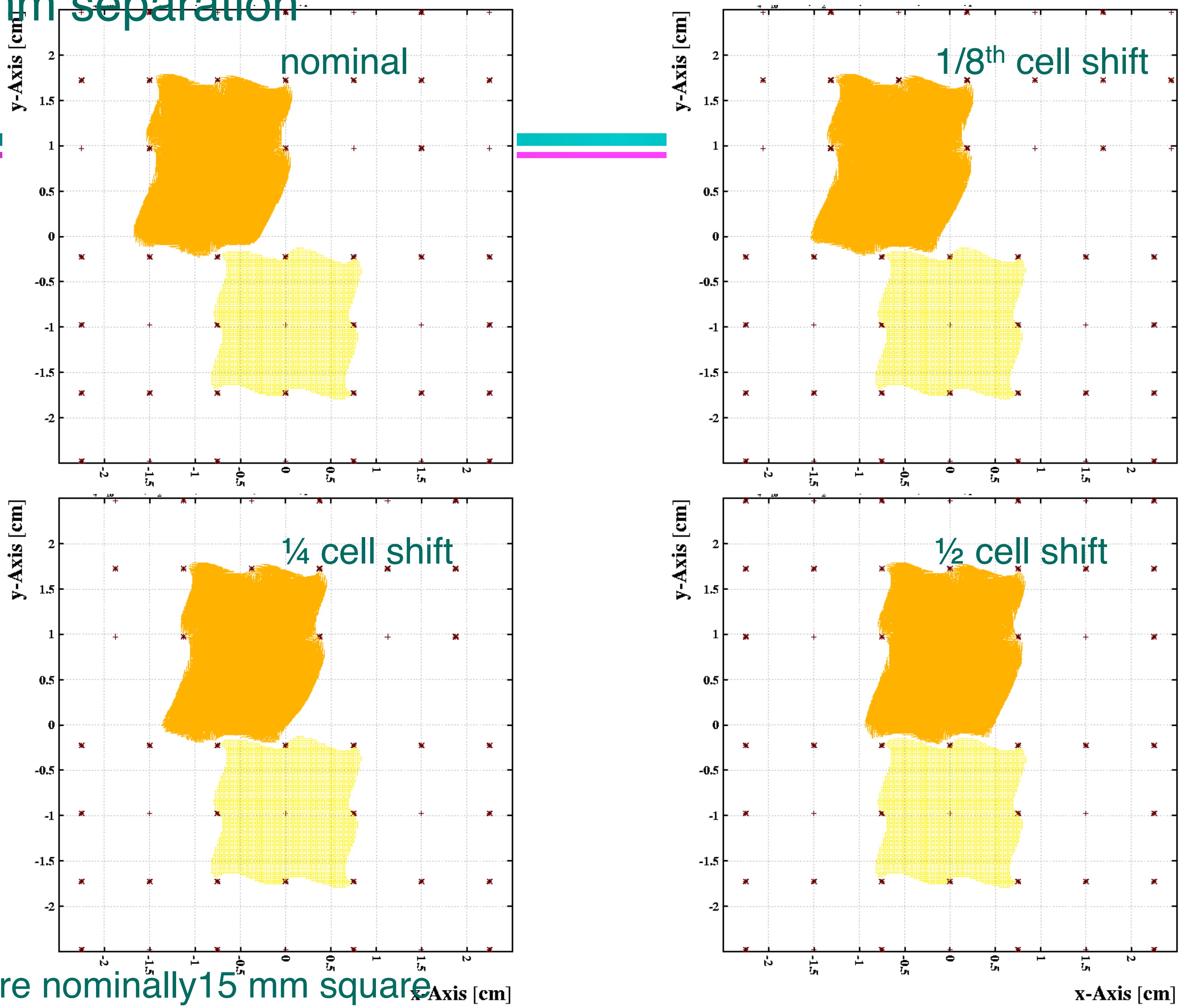
- In the transition between an axial layer and a 50 mrad stereo layer at 510 mm, the radial distance between the sense wires varies by 4.5 mm with z.
- BaBar added guard wires at ? V
- Cases studied; 4.5 mm separation.
  - no guard wires
  - extra field wires (at 0 V)
  - no guard wires, but additional calibration

Axial-stereo layout 1: Field wires at intermediate stereo angle. 4.5 mm separation



cells are nominally15 mm square

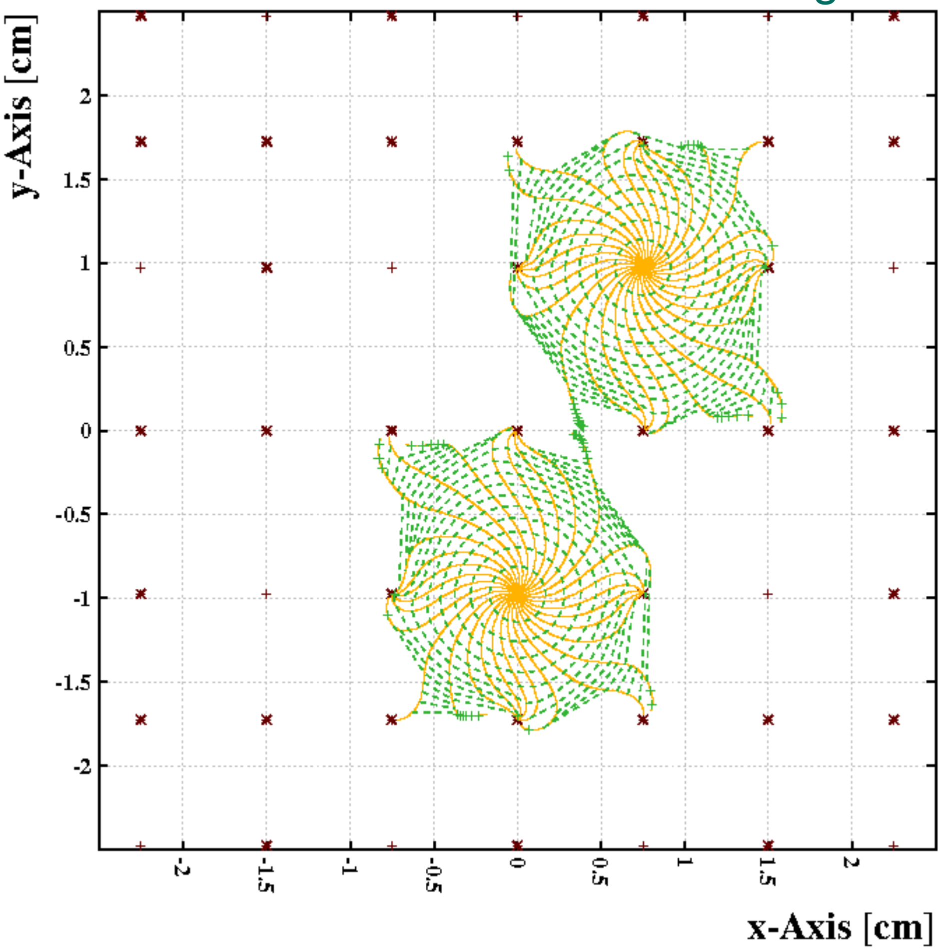
Axial-stereo layout 2: Field wires in phase with lower cell. 4.5 mm separation



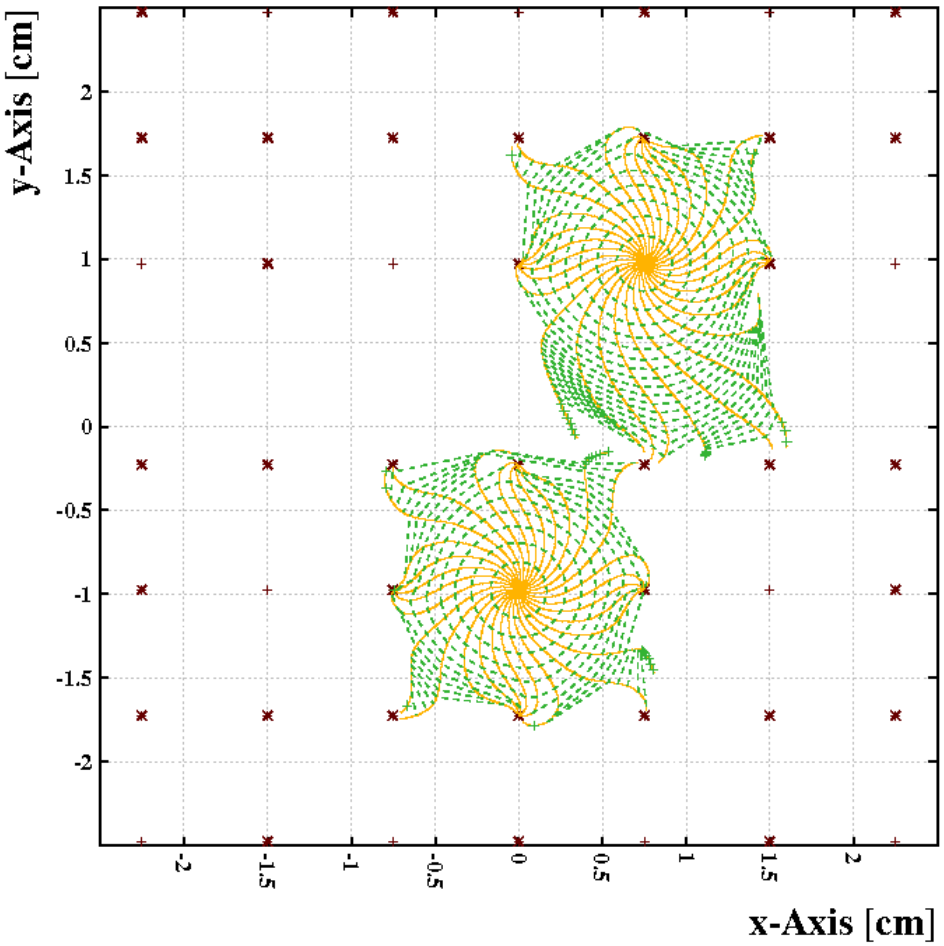
cells are nominally15 mm square

Isochrones for Axial/Stereo SL transition

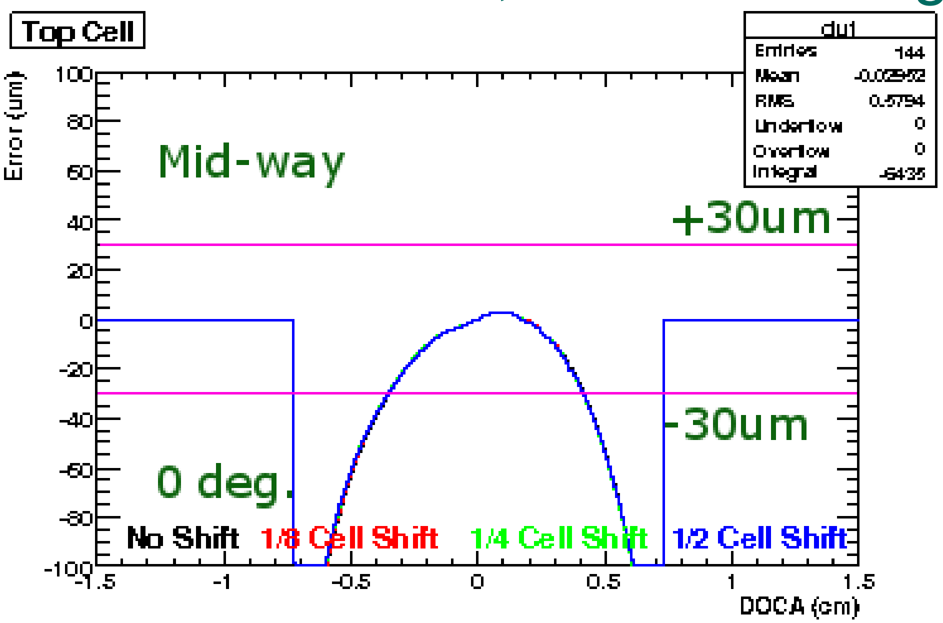
Field wires at intermediate stereo angle

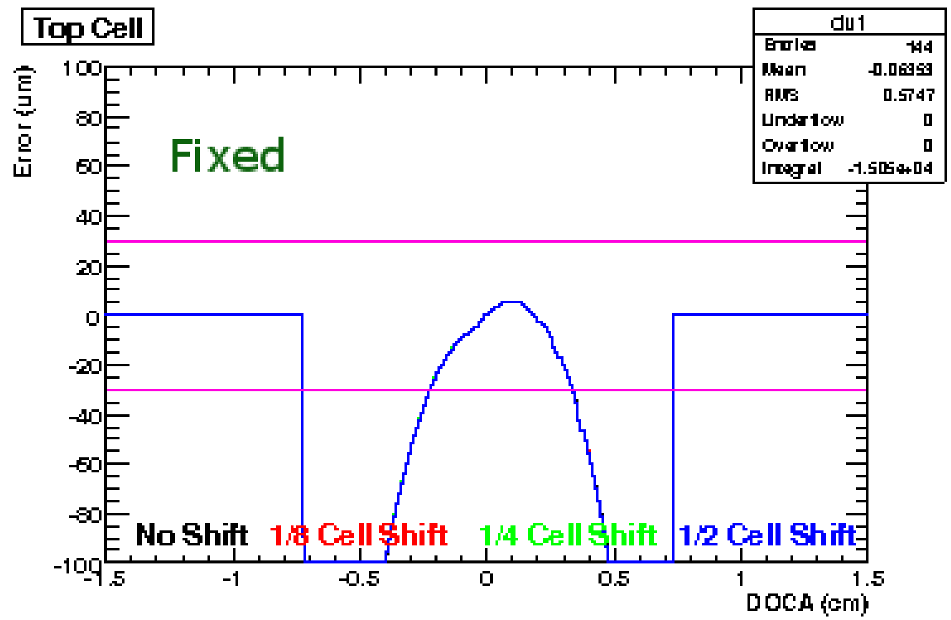


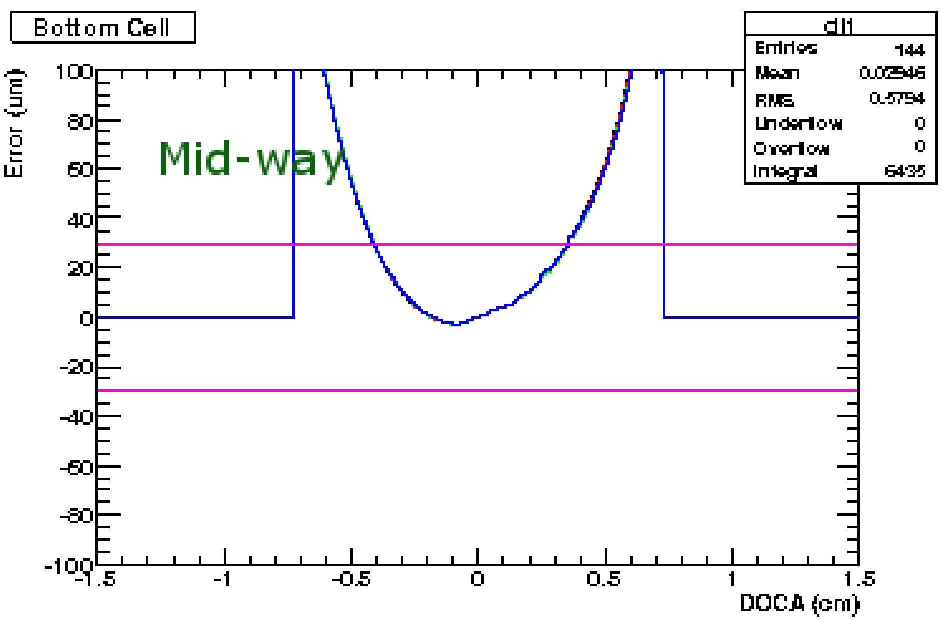
Field wires attached to bottom superlayer

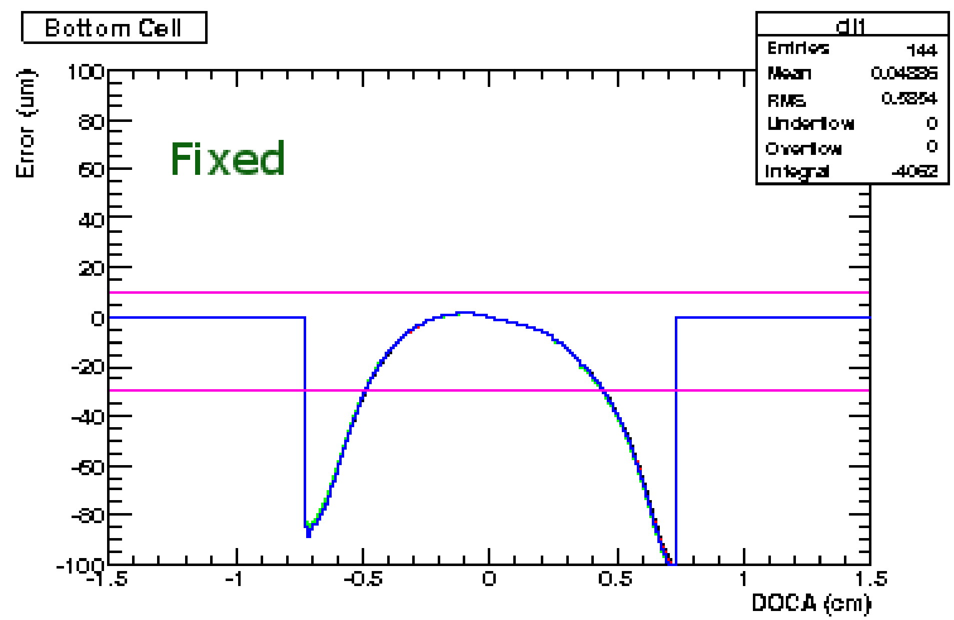


Axial-stereo transition with 4.5 mm separation; no guard wires; use nominal TDR; tracks at 0 deg

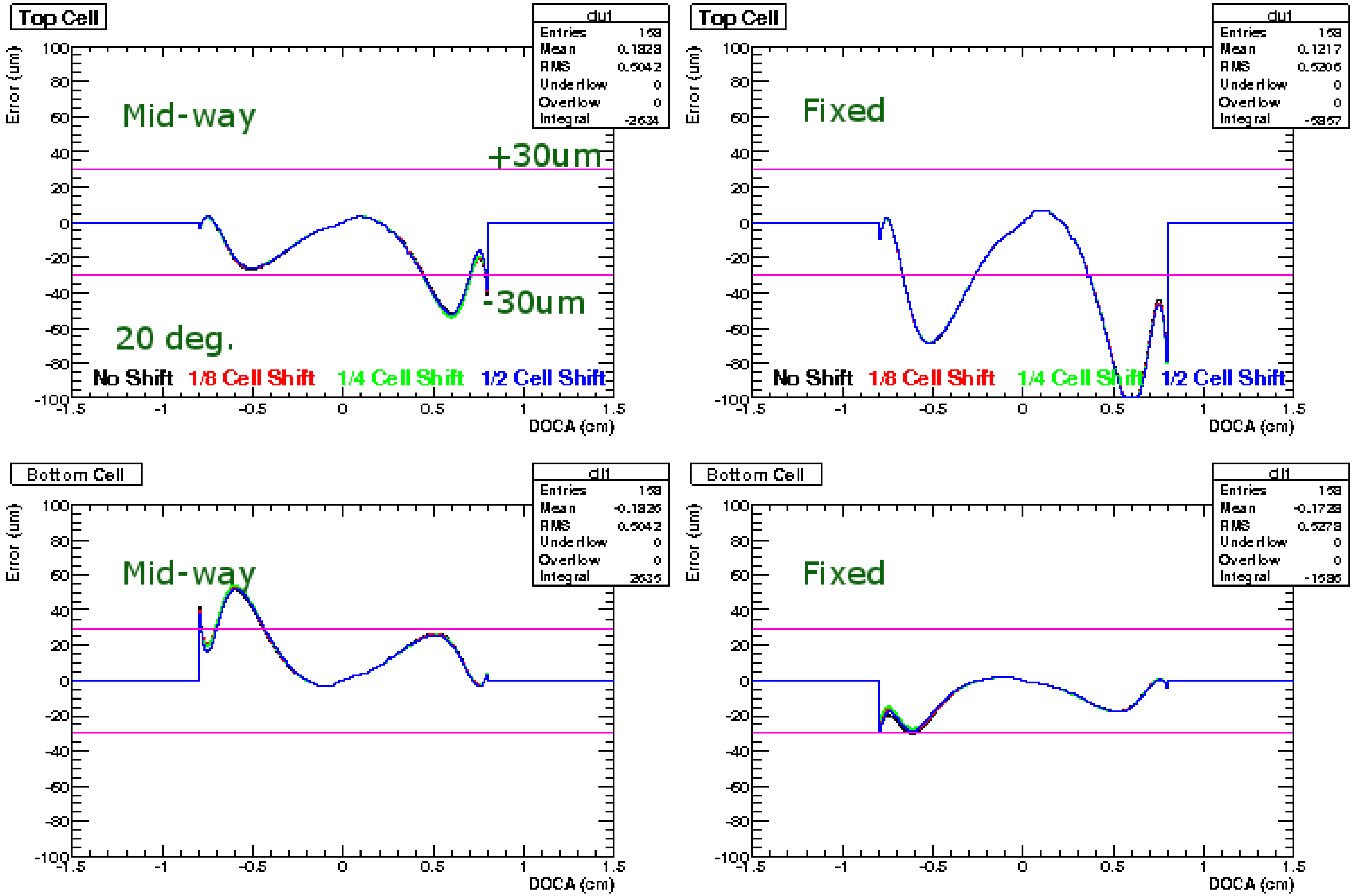




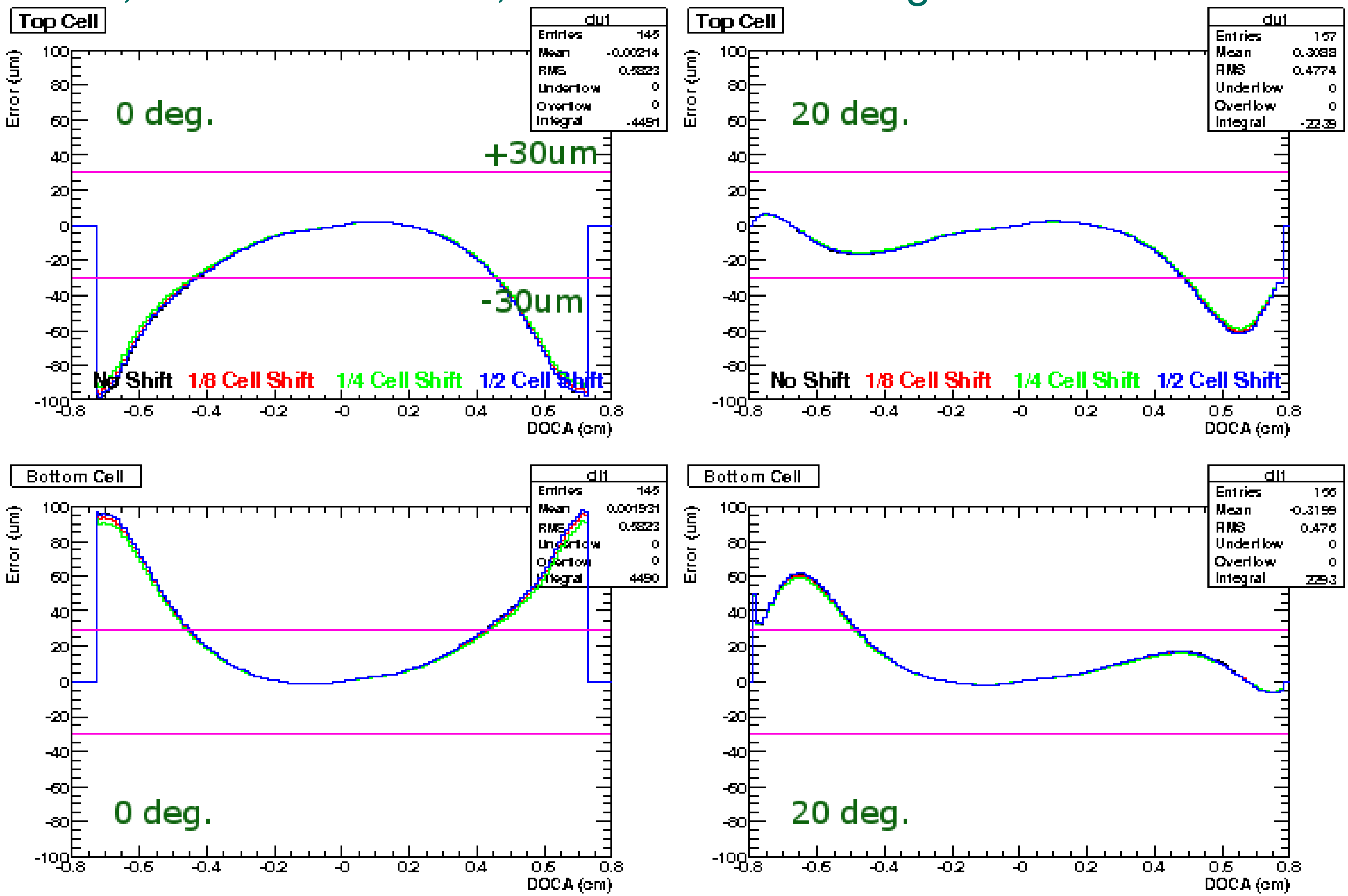




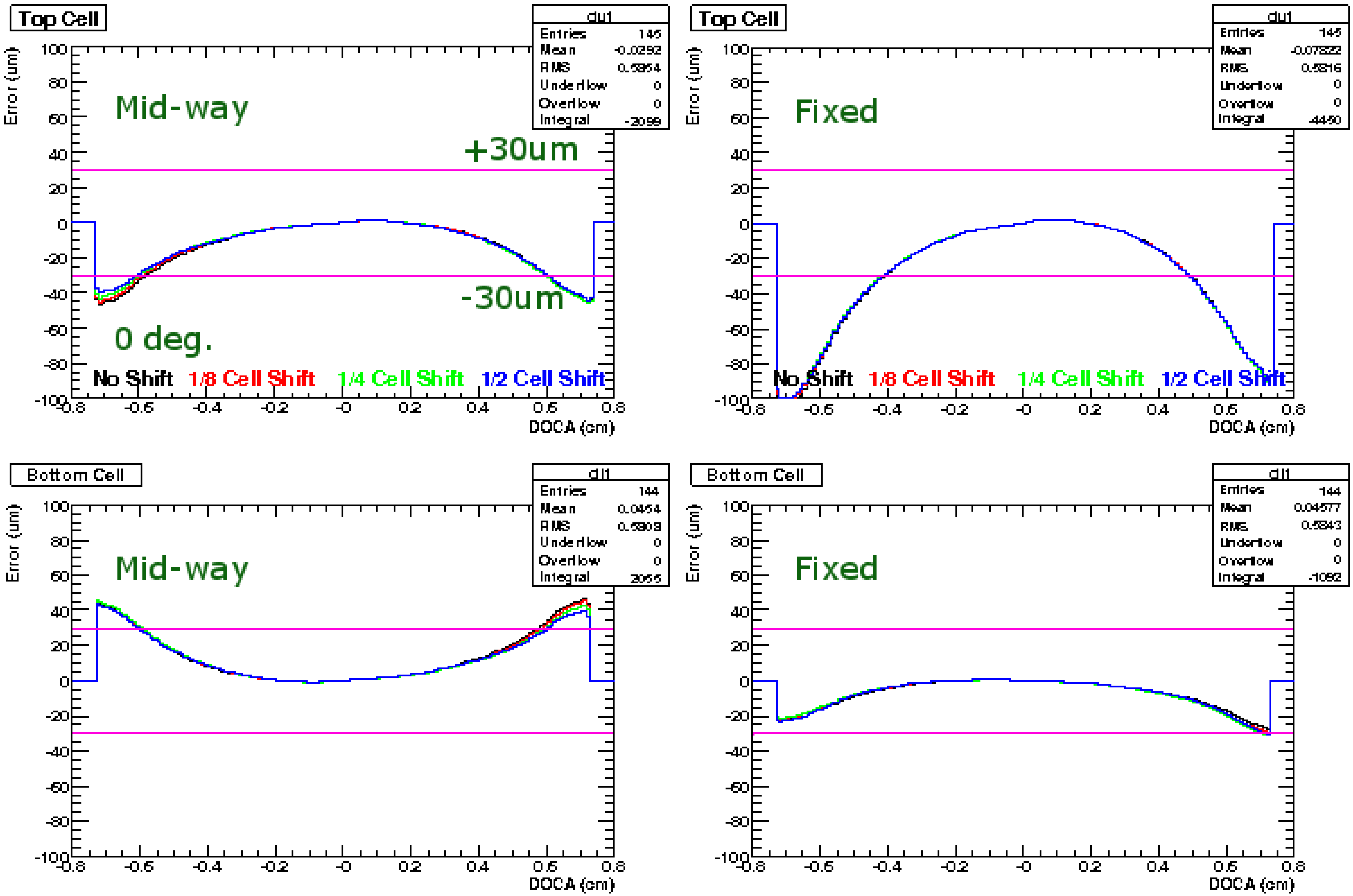
Axial-stereo transition with 4.5 mm separation; no guard wires; use nominal TDR; tracks at 20 deg



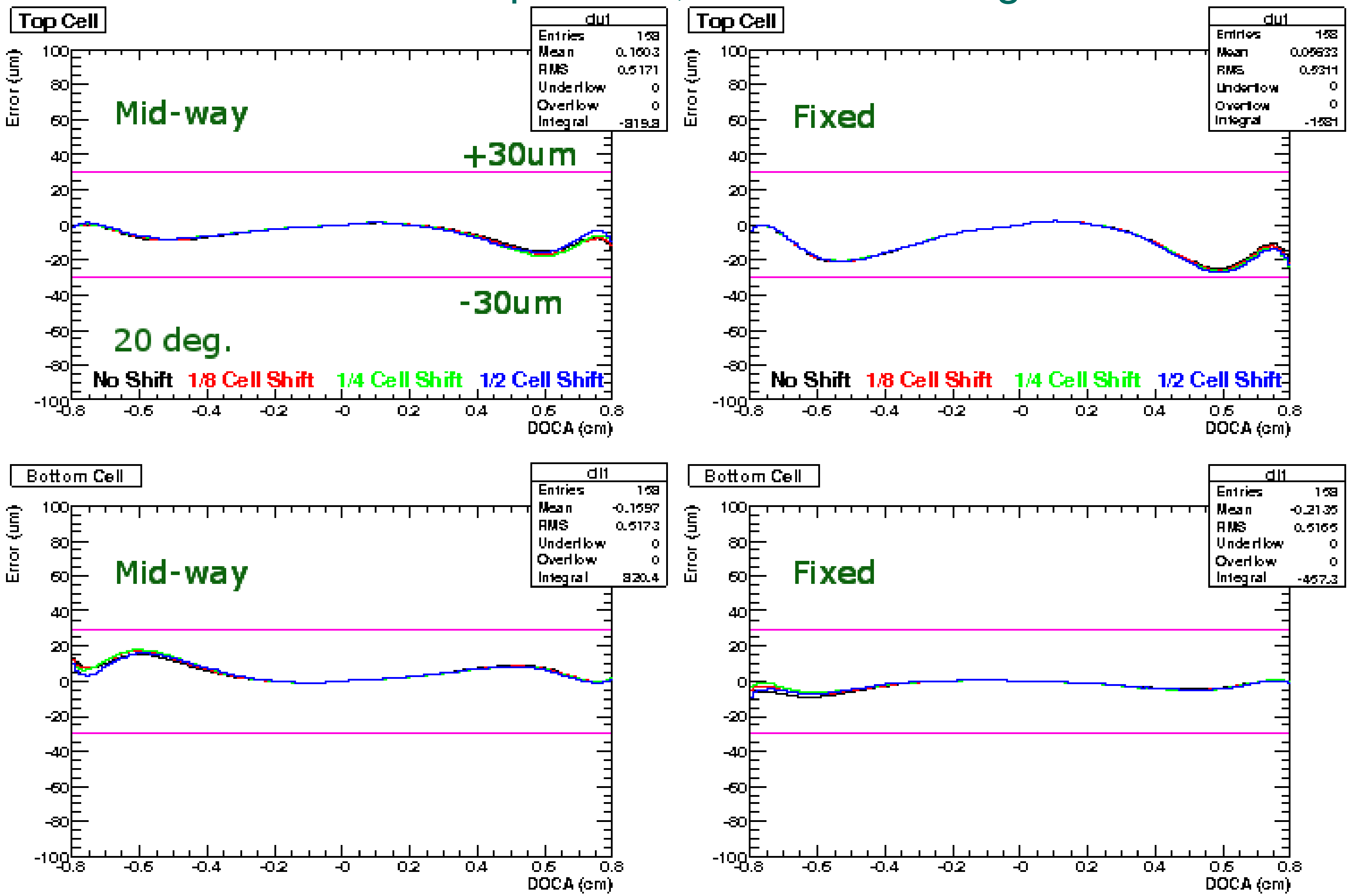
Axial-stereo transition with 4.5 mm separation; extra field wires at 0 V; use nominal TDR; tracks at 0 or 20 deg



Axial-stereo transition with 4.5 mm separation; no guard wires; use TDR from 3.5 mm separation; tracks at 0 deg



Axial-stereo transition with 4.5 mm separation; no guard wires; use TDR from 3.5 mm separation; tracks at 20 deg



Summary on SL transitions

- Stereo-to-stereo transition looks OK without any special effort.
- Axial-stereo is more challenging. I think the last study shows that we can get acceptable performance without guard wires with only a moderate amount of extra work on calibration.
  - we have not demonstrated that guard wires would give significantly better performance
- Eliminating the guard wires reduces material, cost, and construction time.

Results have been written up in technical notes

Suggestions for new studies are welcome

Cell Geometry Studies for the
SuperB Drift Chamber

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September 2, 2010

Introduction

In designing a drift chamber, care must be taken to ascertain the optimal cell shape. From multiple scattering consideration to drift time uniformity to time-to-distance variations, it is important to characterize the advantages and disadvantages of proposed cell designs in these aspects in order to compare and select the optimal cell shape.

For the SuperB drift chamber, we considered the advantages and disadvantages of five different cell geometries with respect to time-to-distance uniformity, dead region, material, end plate tensions, and other considerations. Based on these studies, we recommend the rectangular cell geometry with 3 field wires per each sense wire. We also recommend the use of Beryllium for the inner cylinder, and bare aluminum field wires, in order to reduce multiple scattering.

Tools

Simulation and analysis software was used for this study. The primary simulation tool is **Garfield 9** [1], a program developed by CERN for the simulation of gaseous detectors. Garfield was used to compute surface electric field of wires, drift time of electrons and ions across the cell, as well as determining the active cell volume in the presence of magnetic field, and determine the time-to-distance relationship of each geometry. Data outputs were in either eps graphics format, or tabulated matrix text file to be fed into analyze program later.

In order for Garfield to compute the correct drift time, data on the transport and ionization properties of the selected gas mixtures must be supplied. This was computed with **Magboltz 7.1** [2] program, interfaced directly via Garfield.

Lastly, **ROOT 5.12** [3] was used to analyze tabulated data output from Garfield. Custom scripts were written to parse, analyze, and plot the results.

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Superlayer Transition Studies for the
SuperB Drift Chamber

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September 29, 2010

Introduction

In a drift chamber, the different axial and stereo superlayers introduce azimuthal as well as radial motions between the sense wires that vary along the Z direction. The azimuthal motion manifests as a relative phase shift between the cells of the adjacent superlayers, which applies to both the stereo-to-stereo and the axial-to-stereo transitions. The radial motion manifests as a physical separation between cells in adjacent superlayers, which applies to superlayers that have different stereo angles.

For the SuperB drift chamber, we studied the drift time uniformity and the drift distance reconstruction accuracy for both the stereo-to-stereo and the axial-to-stereo transitions. We found that azimuthal motion is a small effect on the drift time uniformity or the reconstruction accuracy. However, we determined that the radial separation from the axial-to-stereo transition introduces large errors in the reconstruction accuracy, which must be corrected for.

We explored two methods on correcting for the influence of the radial motion. The first is the placement of an extra set of transitional field wires. This method was however found to be insufficient. The second method we attempted is to reconstruct the drift distance using not one but two time-to-distance response curves of different radial separation, the selection of which depends on the actual radial separation of where the interaction took place. This method was deemed to be sufficient to correct for the errors introduced by the radial motion.

We also examined two placement schemes for the transitional field wires at the transition interface. The first method is to place the field wires at a stereo angle midway between the superlayers. The second method is to affix the field wires to one of the superlayers. From our studies, we recommend the midway placement, as it performed best in minimizing the reconstruction errors introduced by the radial motion, which was the most significant source of error.

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